

ON THE DETERMINATION OF DISTORTION IN NUCLEAR EMULSIONS

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ABSTRACT. A method is described by which extensive distortion present in emulsions can be measured and its influence on multiple Coulomb scattering measurements eliminated.

INTRODUCTION

Nuclear emulsions have been known to have distortion, the presence of which severely affects the track contours. Distortion is understood to result from a shear between successive layers of emulsion which is produced by strain created during the processing schedule. Emulsions processed by different methods have been found to have different level and type of distortion.

The first quantitative estimate had been made by Cosyns and Vanderhaeghe (1950). In their method use is made of very steep tracks which acquire a C or S shape as a result of distortion. An elegant method for determination of distortion has been described by Major (1952) and later elaborated by Apostolakis and Major (1957).

The methods enumerated above have been widely used and give a fair indication on the level of distortion as it would affect the shape of tracks limited to a few mm length which is the situation in cosmic-ray exposed plates. With the advent of the machine-accelerated particles tracks of upto a few cm length, and confined to rather a single plane in emulsion, have been obtained. The distortion present in this case has been found to be of an extensive and different nature, (Aditya, 1962). The source of a considerable part of this distortion has been traced to another, namely the flexibility of the pellicle. The corresponding distortion is complicated and cannot be obtained by the methods known earlier.

In the earlier work (Aditya, 1962) the graphical plot method had been used to obtain distortion contours. The principle of the method is illustrated in Fig. 1. It appeared on further analysis that the method could be subjective in so far as the individual judgement on alignment and presence of large angle scatters has to be taken into account. In the present note we describe another method which is not subjective and gives the contour of distortion. The influence of this distortion, as on multiple Coulomb scattering measurements, can be easily taken care of, the procedure for which is described

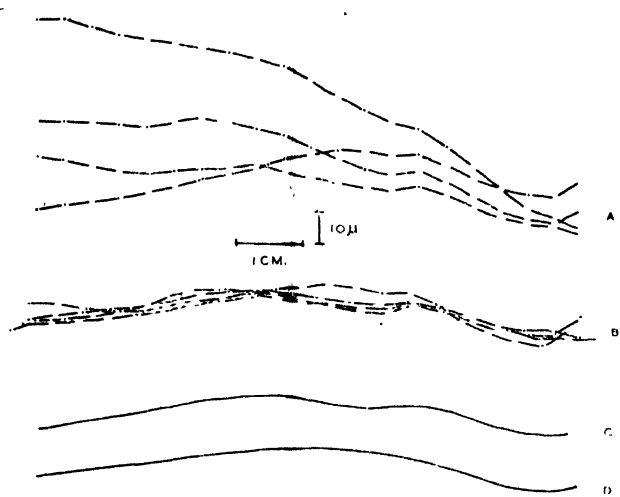


Fig. 1. Schematic explanation for the "graphic-plot" method. Four close tracks, as at (A), are superimposed, (B), from which the common contour (C), is extracted. An over-simplified version, as at (D), could possibly be derived from (C).

THE METHOD

Coordinate measurements for a large number of close tracks are made and second differences, D , taking care of the sign formed, as is conventional. These

TABLE I

	Different tracks				Algebraic mean of rows
Different values along each track.	a_1	$b_1 \dots \dots k_1 \dots \dots n_1$			R_1
	a_2	$b_2 \dots \dots k_2 \dots \dots n_2$			R_2
	a_3	$b_3 \dots \dots k_3 \dots \dots n_3$			
	\vdots	\vdots	\vdots	\vdots	\vdots
	a_j	$b_j \dots \dots k_j \dots \dots n_j$			R_j
	\vdots	\vdots	\vdots	\vdots	\vdots
	a_x	$b_x \dots \dots k_x \dots \dots n_x$			R_x
Algebraic mean of columns	C_a	C_b	C_k	C_n	

are entered in a table, as shown in Table I. $a, b, \dots k, \dots n$, refer to n close tracks, whereas $1, 2, \dots j, \dots x$, refer to the x , D -values on each track. x is evidently equal to $(L/t - 1)$ where L is the length of each track and t is the cell length. For reasonable results x and n should be about 20, each.

If the values D were entirely true scattering, the magnitude and sign of the terms would be random so that the algebraic sum of both rows or columns should be zero. However, if all the tracks have some common contour of distortion, the magnitude of sagitta due to which is larger than the true sagitta, the algebraic sum of both the rows and columns will not be zero. The magnitude of the algebraic mean, R , along the row would be a direct function of the magnitude of correlation and the sign will indicate how the shape varies. The R values could thus vary rapidly both in magnitude and sign. Moreover, the algebraic sum, C , of the columns will have the same trend for all correlated tracks and would be zero if the distortion contour was equally distributed around a linear average, such as for an S -shape distortion of equal sagitta in the two halves or for a complicated contour. It would not be zero for a C -shaped distortion, for example. It is evident that the algebraic mean of the rows is the main quantity of interest.

The distortion contour can be obtained from the algebraic mean of the rows, $R_1, R_2, \dots R_j, \dots R_x$, by back integration, and twice, since this procedure is the reverse of the forming of second differences.* A point need be made here of the influence of large angle scatters on the tracks. The presence of a large angle scatters will affect one or two values of D , and can be detected by subtracting

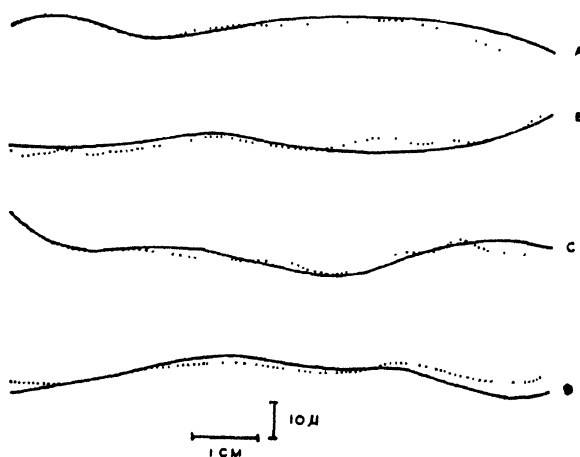


Fig. 2. Distortion contours of four samples as obtained by two methods : Graphical-plot method (solid line) and the method of Algebraic-mean (dotted line).

* P. M. Sood, Chandigarh (private communication) has intimated that such a procedure had been suggested to him also by E. Dahl-Jensen, Copenhagen (private communication).

the algebraic mean from such suspected regions of scatter. A cut at the conventional 4 times the expected scattering sagitta will remove the large angle scatters. A modified algebraic mean may be found through successive steps, if required.

Some of the distortion contours (dotted lines) obtained by the method described above and those by the graphical-plot method (full lines) are shown in Fig. 2. The measurements had been made in 600μ G 5 emulsions exposed to 27 GeV protons. Excellent agreement is found between the two methods. The contours are seen to be varying continuously in direction and magnitude.

ELIMINATION OF THE INFLUENCE OF DISTORTION

It is evident that the true scattering sagitta can be obtained by point to point subtraction of the distortion contour from the track coordinates. This procedure is not essential unless one is keen to look at the contour of distortion itself, because the algebraic mean along a row (corrected for large angle scatters) subtracted from the D values in the corresponding row directly gives the second differences for true scattering, perhaps with a little more noise.

In an earlier work, (Aditya *et al.* 1961, 1963) for samples having very large spurious scattering, the algebraic mean along the rows was found to be of very large magnitude and gradually changing sign. On the basis of the results of a later work (Aditya 1962), this behaviour can be attributed to presence of large

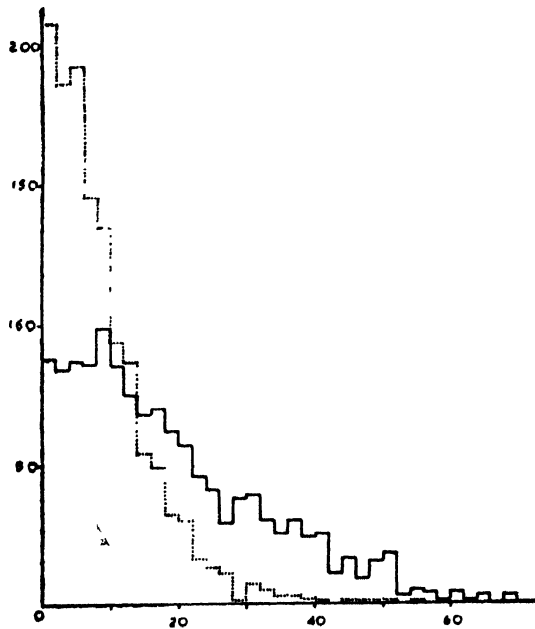


Fig. 3. Frequency histograms for 1285 scatters of 4 mm cell length over 27 GeV protons. Full line : observed data, excluding three scatters at 81, 83 and 95 respectively. Dotted line : corrected data, after distortion elimination.

distortion. We have found that by the process described above $D_{observed}$, which was originally 2.5 times the $D_{expected}$, got reduced to 1.1 times, thereby eliminating almost the entire spurious scattering, see, for example, Fig. 3 for the observed and corrected frequency histograms. Whatever remains is due to the variation of distortion contour along depth. This, however, is not detrimental since this small spurious signal is expected to constitute a little increased noise level and can be quadratically subtracted.

In agreement with the findings of Aditya (1962) the magnitude and nature of spurious scattering has been recently shown (Aditya and Puri, (1964) to be a very close function of this distortion. Use of this method has also been made in another work (Aditya 1964) with great success.

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